# CHAPTER III. FACTORS AFFECTING THE ION-EXCHANGE PROCESS

The effectiveness of the IX process depends principally on softening and regeneration factors. These factors, along with a brief explanation of the probable effects they have on the hardness removal capacity of the resin, are discussed below.

1. Softening factors

   a. Hardness ion concentration. For a given hydraulic loading rate, as the hardness concentration of influent feedwater increases, the capacity of the resin (total amount of hardness removed) decreases while the leakage (amount of hardness in the effluent process water) through the bed increases. The lower the hardness leakage, the better the system's performance.

   b. Sodium-to-hardness ion ratio. Sodium ions compete with hardness ions for space on the resin. As the sodium-hardness ratio increases, the resin's ability to remove hardness decreases and hardness leakage through the bed increases.

   c. Total dissolved solids. As the total dissolved solids concentration increases, the resin's capacity decreases and leakage through the bed increases.

   d. Temperature. An increase in temperature generally increases the resin's ability to remove hardness and decreases hardness leakage.

   e. Hydraulic loading rate. High loading rates may cause channeling through the IX columns, resulting in lower service (softening) durations because the entire bed is not being used for softening.

2. Regeneration factors

   a. Type of brine. The brine (sodium chloride or a desalting process reject) used for regeneration determines the regeneration mode. Standard softening practices use sodium chloride brine for regeneration. The use of a desalting process' reject brine for regeneration is experimental in nature and requires a special regeneration procedure in which a portion of the reject brine is used more than once. Some constituents of the reject brine may inhibit the regeneration process.

   b. Concentration of brine. As the concentration of sodium within the brine increases, the capacity of the resin is generally increased until a concentration is reached that results in a maximum resin capacity. Once past this "optimum" concentration, the brine approaches saturation and tends to cause resin shrinkage and inhibit the migration of ions both into and out of the solid phase. At brine strengths below optimum range, fewer sodium ions are available at any one time to displace hardness ions, and regeneration is less efficient.

c. Brine contact time. Contact time is the interval between the first contact of the brine with the resin and the moment the brine is rinsed from the resin bed. Resin capacity increases as the contact time increases, until contact time provides no additional advantage for a given brine concentration and hydraulic loading rate.

d. Hydraulic loading rate. High loading rates may cause channeling through the bed and result in unequal resin regeneration.

# CHAPTER IV. DESCRIPTION OF FACILITIES

The IX system was comprised of two identical skid-mounted units. Process water was pumped from the filter clearwells, dechlorinated, processed through the IX units, and rechlorinated before entering the IX clearwells. Regeneration of the IX units was accomplished by pumping brine (recycled and fresh) through the IX units. Design of the system also allowed for upflow, counter-current regeneration.

Each unit had two vertical, cylindrical columns (5 feet in diameter and 8 feet high) in parallel. Internally, each column was fitted with three water distribution manifolds at the top, middle, and bottom levels. The manifolds were designed to maintain even flow distributions through the bed to prevent channeling of the flows through the tanks. The manifolds consisted of a 3-inch-diameter header with 1-inch-diameter laterals. The upper and middle manifold headers were made of Schedule 80 PVC; the bottom header was made of steel. All laterals were made of Schedule 80 PVC and wrapped with PVC screen to prevent resin loss.

Each column contained the high-capacity, polystyrene-sulfonated, strong-acid, cationic exchange resin. The depth of the exchange resin was 5 feet, which corresponded to a volume of 85 cubic feet per column.

Control valves regulated flows into the columns. Each unit had five control valves with different flowrates. Two valves regulated service and rinse event flows; the remaining three regulated flows for various regeneration and backwashing events. All flow valves were interchangeable. For testing purposes, three auxiliary control valves were supplied for both units.

The units werre capable of upflow regeneration without fluidization using air as the method of resin holddown. An advantage of resin holddown over fluidized-bed regeneration is closer contact between regenerant and resin, resulting in higher mass transfer rates and increased resin capacities. In addition, higher regenerant flowrates allow for faster regeneration and higher service factor time.

The IX units contained numerous electrically operated valves and pumps. During the IX cycle, the resin bed underwent servicing, backwashing, regenerating, draining, and rinsing. A microprocessor unit controlled most functions of the IX system. Flow schematics for softening and regeneration for the IX system at the Los Banos facility are shown in Figures 2 and 3, respectively.

The two IX units were designed to be operated in sequence so that one unit was always in service while the other was in regeneration or standby, thus ensuring a continuous supply of softened process water.

Because the presence of excessive amounts of chlorine in the process water can result in gradual swelling and subsequent capacity decline of exchange resin, each IX unit was equipped with a dechlorination system consisting of a chemical injection pump and a 100-gallon batch solution tank. A sodium bisulfite solution was injected into the process water during backwashing, rinsing, and servicing before the water entered the IX unit columns.

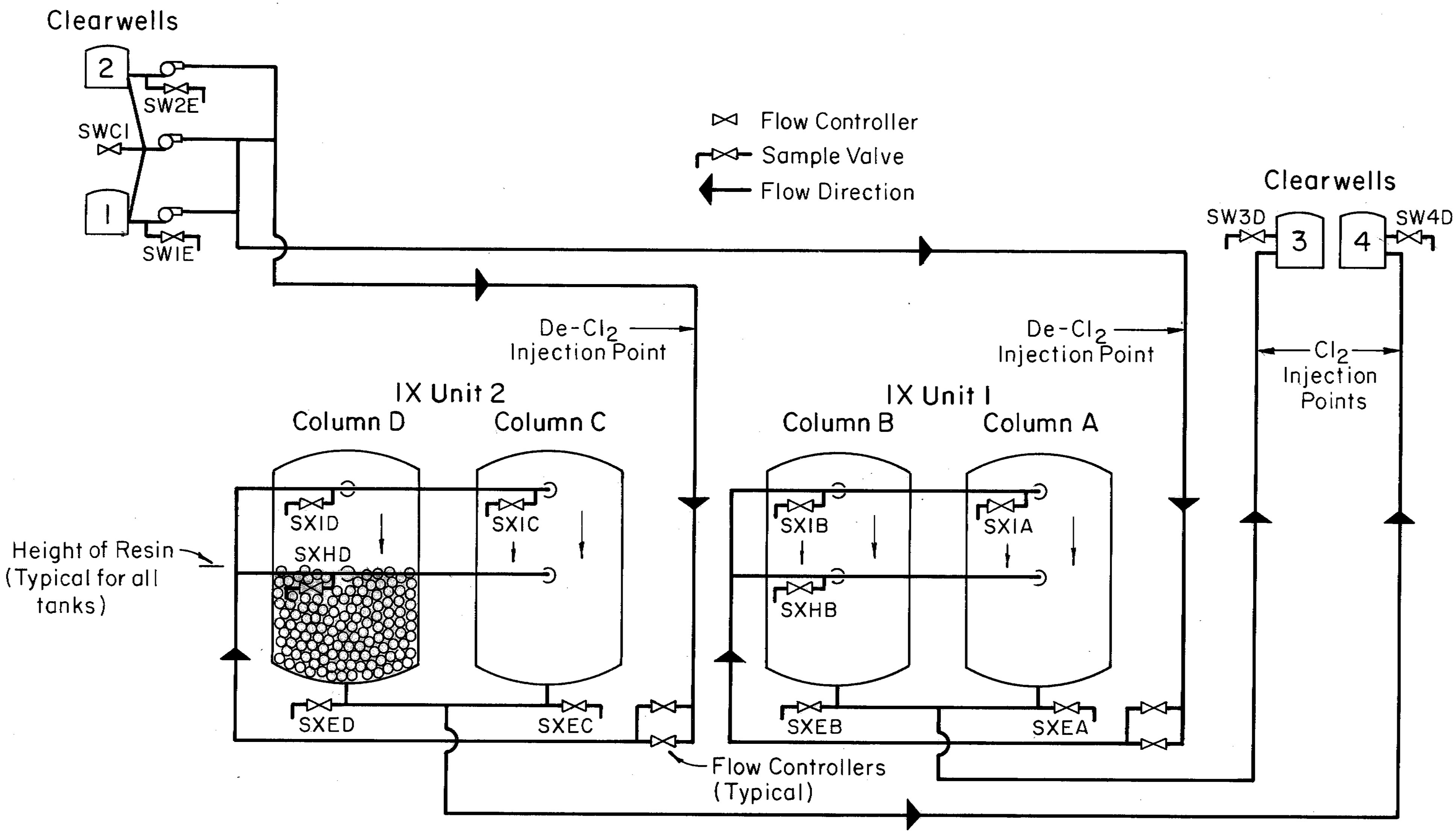


Figure 2. Ion Exchange Process Flow – Softening

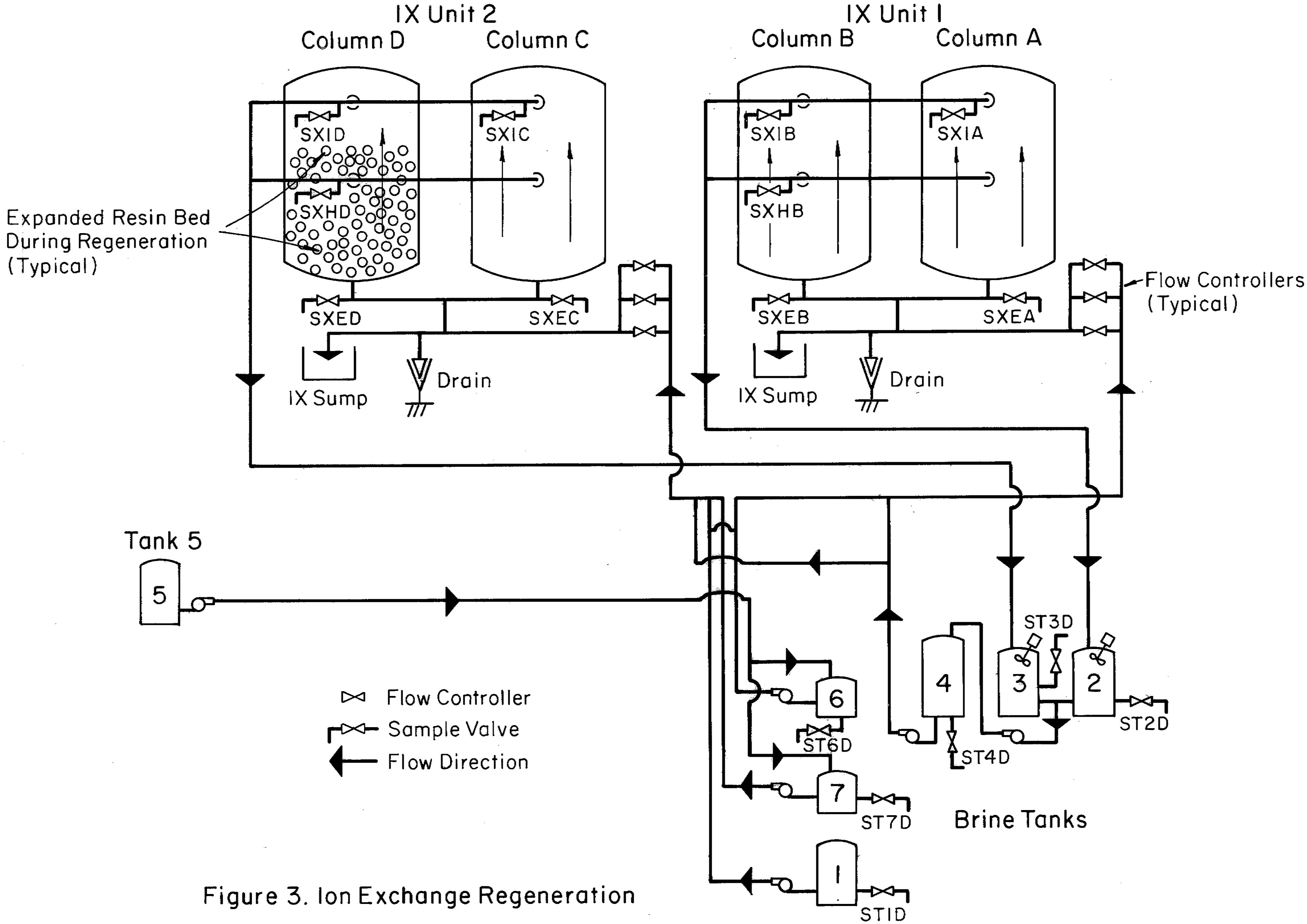


Figure 3. Ion Exchange Regeneration

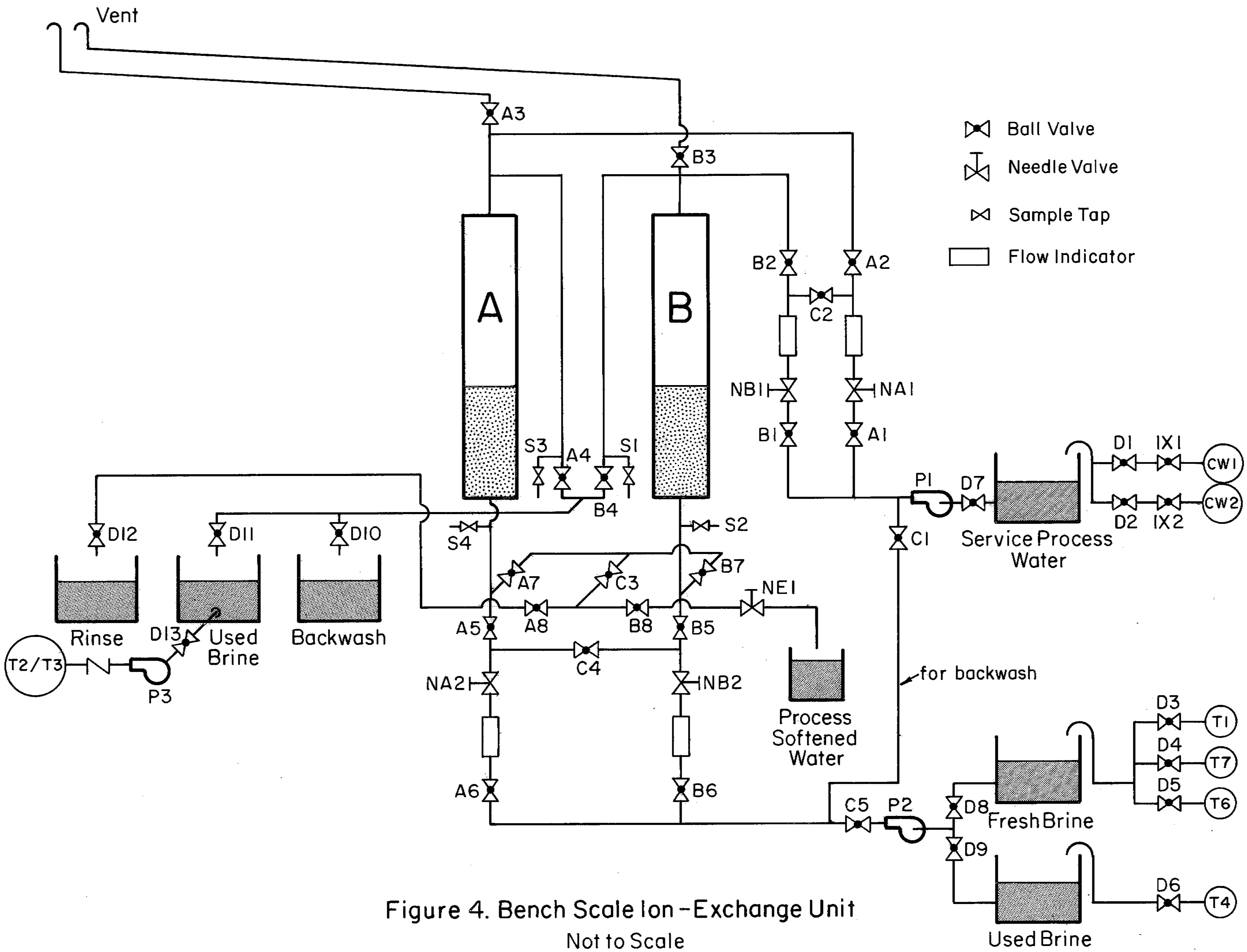


Figure 4. Bench Scale Ion-Exchange Unit
Not to Scale

A bench-scale IX unit was installed at the plant when the main units were not in operation because of the construction of the IX sump and associated facilities. The bench unit was used extensively to simulate and develop the main unit's eventual operation cycles.

The bench unit consisted of two columns 3 inches in diameter, 8 feet high, and plumbed so that they could be operated separately or in parallel. The depth of resin in each column was approximately 5 feet. A schematic of the bench unit is shown on Figure 4.